been elevated, and then the sands and gravels and clays of the terraces heaped above his remains,—that he was a fossil, unchanged and undisturbed, centuries perhaps before the Mastodons and Mammoths, whose bones were found in the peat deposits of N. America, including the tooth and thigh bone found in Cape Breton, which has been referred by Geologists to the later genus, had begun their existence.

ART. XI.—AGRICULTURE ALLIED TO CHEMISTRY. BY A. P. REID, M. D., L. R. C. S., EDIN., &c.

(*Read before the Institute Dec.* 9, 1873.)

IN taking up this subject, I do not expect to give anything new, or broach any form of theory, but rather to give a resumé of the previous and present ideas that to a great extent rule with those who have paid most attention to the scientific cultivation of the soil.

Previous to the present century these sciences were held to have but few links in common, the authorities in either, with few exceptions, did not trespass their imaginary boundary line. Even Sir Humphrey Davy in his lectures on the "Elements of Agricultural Chemistry," (1802–1812), did but shew that there was a relation between the *science* of Chemistry and the *art* of Agriculture.

Strange to say Boussingault, in 1836, after long study, experience and observation, came to the conclusion that the value of manure was to a great extent indicated by the amount of nitrogen and ammonia it contained—a theory that was rudely shaken to the winds by the accomplished Liebig; but it has again asserted itself, and is not likely to be displaced, for experience has proved the security of its foundation, and the accuracy of the study and observations of its founder.

In 1840 Liebig propounded a most comprehensive, clear and definite theory of plant nutrition that took the agricultural world by storm and ruled for years, but it vanished, and was even given up by its illustrious founder, long ere his late decease. I will very briefly run over its landmarks, for it had much to do with the extended and accurate observations of the past thirty years.

The old idea, advocated by Sir H. Davy, was that plants derived their gaseous nutrition (carbon, hydrogen, nitrogen, and oxygen) from *humus*, a constituent of all productive soils. Boussingault taught that plants obtained these elements both from the air and soil, but could not solely depend on either source for their requirements. That notably the nitrogen and ammonia in the air had to be supplemented by these substances if not existent in the soil.

Liebig taught that the food of the chief mass of the plant (carbon, hydrogen, oxygen, nitrogen) consisted solely of carbonic acid, water and ammonia. That these were altogether obtained from the atmosphere, which was abundantly supplied by the decay of animals and vegetables, their decomposition giving off these substances to the air. That thus is produced much more oxygen than plants can use, and hence this gas so absolutely necessary for the maintenance of life had its supply kept up by plant growth. The decomposition of carbonic acid depositing carbon in the tissue of the plant and giving off oxygen to the air. That the only substances furnished by the soil were the "ash constituents" of the vegetable, or the mineral matter it contained. That these alone were all that were necessary to be supplied to the land, as they were all that were taken from it. That manures were only of value in proportion as they contained the mineral or ash constituents of the crops they were intended to nourish.

All of these ideas of Liebig are yet believed to be and are correct, the only error being that they were made too exclusive. Plants do absorb and assimilate carbonic acid, water and ammonia from the air, but they require a portion from the soil as well, and hence manures containing these, or equivalents, are demanded.

The ashes of the plants or mineral constituents are derived from the soil, in which they must exist in a state capable of being dissolved in water, and there is need for their return in this form to keep up productiveness. In this particular a good soil is an extensive deposit that may be drawn on for many, many years, without showing very marked deterioration. For good husbandry exposing it to the air, causes the insoluble salts of silica, potassa, lime, phosphates, &c., to be decomposed, and in addition much ammonia is absorbed from the air and retained, this being a property of all well tilled soils. The other gaseous or aerial constituents, and a large portion of the nitrogen are not so renewed, and hence need the most frequent repletion and must be furnished in the largest percentage by the most profitable manures. In fact we have returned to the previous theory of Boussingault.

The ash of plants contains potassa, soda, lime, magnesia, iron, phosphoric and sulphuric acids, silica, &c., &c., derived from the soil. Liebig taught "supply these in a soluble form in sufficient quantity and the plant demands nothing more in the way of food; with these it is able to assimilate carbonic acid, water and ammonia from the air, without them it cannot." Liebig's "Mineral Manures" were the natural outcrops of such teaching,—much was expected from them, but comparative failure resulted.

Farmers voted sientific agriculture a delusion and returned to the good old way that had been handed down from father to son for ages, and yet they could see that their lands were getting run out though knowing not how to correct their condition.

No country demands more from its soil than Great Britain, and no people are better qualified to reduce theories to a financial basis; hence it is natural that we should look to England for correct practical as well as scientific agriculture. To get the grains of truth out of the mass of chaff abounding in all theories, and as well to still farther enlarge the domain of our knowledge, an experimental farm at Rothamsted, England, was carried on for over 20 years (from 1843 to 1864, when reports were given) by Lawes and Gilbert. They gave to the world the most practical and scientific agriculture that had yet obtained, and whose results stand the test of continued experience. Every conceivable theory and experiment was tried and the results given in plain and explicit figures and opinions. To these as I am able to understand them, and as briefly as possibly, I would wish to direct your attention.

Continued crops of the same kind without manure and from the same soil, exhaust the soluble ash constituents demanded by that plant and as well the organic elements it requires for food, and that are present in more or less quantity in all soils.

Rotation of crops is good husbandry, because different plants require different mineral food, and a soil deficient for one plant may have abundance of what is wanted for another. The waste of one crop that decays on the land or is returned as farm yard manure furnishes food for the one that follows, and the tillage, by exposure of the minerals of the soil to the air and sun and rain, promotes their decomposition and consequent solubility, while facilitating its power of absorbing ammonia from the atmosphere. In this way is utilized a portion of the vast reserve of minerals or ash constituents present in all soils, the soluble part of which had been more or less removed by previous cropping.

Regarding the influence of manure, it requires some variation owing to the kind of crop, and different manures are suitable at different stages of the growth of the same plant. Phosphoric acid, potash and ammonia are largely demanded by all crops, and soils are most rapidly exhausted of these constituents.

Farmyard manure is the most universally applicable, but its supply is very limited in proportion to its demand. It can be aided or even supplemented by the judicious use of substances containing nitrogen, such as guano, sulphate of ammonia, nitrate of soda, rape cake, &c., and those containing phosphoric acid, such as apatite, coprolites, bones or animal matter, superphosphate of lime, mixed phosphates containing lime, magnesia, potash and ammonia, as in "artificial" manures, guano, and those containing potash, as the ashes of plants.

Wheat and cereals demand a very large proportionate amount of ammonia and next of phosphoric acid—silica, lime, etc., being generally present in sufficient quantity. Potash is also largely supplied by most soils.

Turnips and root crops, though having as large a percentage of nitrogen as cereals, and also the marked property of absorbing ammonia from the atmosphere, and thus getting a quantum of nitrogen, do not require it so much as manure. It is very serviceable after the plants have attained a vigorous growth, and should be combined with carbonaceous manures and placed not too near the seed, as their presence is prejudicial at an early stage, though most necessary when approaching maturity for the development of the weight of the bulb. The soluble phosphates are the most demanded by turnips and root crops at an early stage of growth to promote active development, but are not needed as they approach maturity for they do not increase the weight of the bulb.

Phosphates alone used as manure are not successful. The amount of phosphoric acid in the turnip crop is not larger than it is in the wheat crop, yet experience teaches that a direct supply of soluble phosphates is more influential in promoting the growth of the turnip than wheat, and hence they must exercise some important function in its development.

To give an idea of the amount of material obtained by crops from the soil as minerals, and the amount of soluble mineral or ash constituent present, and that obtained from the air and soil as gaseous or aerial, or as often termed organic constituents, I present a table which I have compiled from those given by Magnus and Lawes and Gilbert,—and as well as analysis of the soil. The quantity of each constituent is given in pounds weight, and they exist of course in combination though spoken of as in the free state. Straw and grain are included in the analysis.

	Phosphoric Acid.	Potash.	Lime.	Magnesia.	Silica.	Totals.	Nitrogen.	Dry Crop.
Per acre of soil one foot deep, soluble in acid—lbs	7581	8983	35794	10180	17920	80468	10	
Average annual Wheat crop (35 bushels), lbs. per acre....	3–73	12–73	4–72	1–89	61–3	94		
Wheat 30 bushels per acre—lbs.	23	29	9	6	102	182	51	4080
Barley, 40 " " "	20	30	12	7	88	171	50	3891
Oats, 44 " " "	16	31	12	8	90	184	56	3515
Beans, 34 " " "	29	52	32	11	6	102	113	3777
Turnips, 10 tons " "	20	89	60	4	3	289	77	2957
Clover, 5000 lbs. per acre	28	75	121	32	11	373	124	4150

In no part of the Dominion are correct ideas of the chemistry of agriculture more needed than in Nova Scotia, where many farms are quite run out. I have seen thousands of acres lying waste in different parts of the province, and on enquiring the cause from those in the vicinity they said, "the land was spent and not worth the trouble of tillage, though it had at one time been good."

The rotation of crops and manures which obtain in England are not on that account necessary for Nova Scotia, but the principles which dictate and the occasions which demand rotation are precisely the same. The composition of our soils may vary from those of Great Britain, but good tillage and judgment in the selection of appropriate manures for plant food are as necessary for the one as the other.

To assert that Nova Scotian farms want the same manures and crop rotation as Rothamsted would be haphazard, but to say that our farms want as good tillage and as careful experimenting is simply a statement of fact.

The soils of Nova Scotia are extremely varied, and their chemical analyses are not alone sufficient upon which to build a perfect system of agriculture. Because though chemistry may give all the constituents in their natural state of aggregation, it cannot positively state the influence on each of tillage and exposure to the air with the acquired solubility of its minerals. However it can suggest the most likely experiments to be tried in the way of manures and crops.

A rotation of crops applicable to most soils is the alternating of cereals with roots, vetches and clover, as these possess marked superiority in absorbing ammonia from the atmosphere, and as well of assimilating the nitrogen, and thus enrich the soil for a grain crop by the products of their decay, while their accompanying tillage has increased the soluble minerals from the vast insoluble reserve that makes up the mass of clay and sand and loam to which we give the general name of *soil*. Careful and intelligent agricultural experiments by the agricultural societies on the granitic, plaster, and alluvial soils of our province, would before many years bring unwonted fertility to our farms, and the demand for manures, whether phosphatic or ammoniacal could be freely supplied by the resources of our own province.

There is an old and very erroneous saying that "any kind of a man is good enough to make a farmer of," but even limited experience will convince that there is no human calling that can give as good and continuous return for the capital and intelligence invested, as the farm. I could not say to Nova Scotian farmers buy a book and immediately set to work on what is wrongly styled *scientific* farming, for failure would be the probability. But rather study up the best authorities on agriculture, and set apart five or even one or two acres upon which to experiment with all varieties of crop and manure that would hold out prospects of success. Thus there would be no fear of incurring any serious loss or disappointment. It takes energy and patience with study both of chemistry and agriculture to make a good experimenter on a plot of one acre, and this method alone when thoroughly and repeatedly worked out can give success on the more extended area of the farm.

Young men designing to enter on an agricultural career would need to devote as much time to education if success is to be assured, as would be needed if they intended adopting the professions so called. For it is an extensive and complicated subject, and can give scope to the most accomplished intellect in studying its mysteries.

Chemistry does and will do much for agriculture; it explains the changes taking place in and products resulting from vegetation; it gives, in competent hands, the composition of the active constituents of the soil and suggests the most appropriate additions thereto, or in other words directs EXPERIMENT, the crucial and TRUSTWORTHY TEST.

When the demand becomes sufficiently extensive for commercial success, it will produce the necessary plant food in soluble form from apatite rock, phosphates from the so called *marle* deposits existing in the province, from the bones and animal substances that now go to waste, from ammoniacal gas liquor, sewage, sea weed, and such like, that are mines of wealth to the farmer as well as manufacturer, when the occasion calls forth some of the resources of Chemistry.

ART. XII.—EVOLUTION. BY ANGUS ROSS, ESQ.

EACH animal* begins life at the same point of departure—the egg—with every other, and certainly all the *Vertebrata*, in the early stages of their development, pass through apparently precisely the same transformations, but all except man at some stage become specialized: he alone continuing a course of harmonious develop-

* Except certain of the lower Grades in which a whole community is developed from the product of a single egg, by budding, subdivision, &c.